NOx Control Cost Effectiveness Estimate

Engine Manufacturer	Cooper-Rolls
Model No.	Coberra 125
Engine Type	
Fuel Used	Natural Gas
Emissions Control	SCR
Combustion Control Purpose	NOx
Target Reduction	75%

Color Legend

User Data / Information Input Cell
"Cumulative" Cost Cell for Primary Categories
Cost Effectiveness ($ / ton)

1 Engine Design Conditions

			Comments
Power Output	14300	(hp)	Rated HP
Engine Exhaust Temperature		(F)	*optional input*
Engine Exhaust Rate		(lb/hr)	*optional input*
Gas Volume		(dscfm)	*optional input*

2 Full Load Engine Exhaust Composition:

			Comments
Oxygen (O_2)		(vol. %)	*optional input*
Carbon Dioxide (CO_2)		(vol. %)	*optional input*
Water (H_2O)		(vol. %)	*optional input*
Oxides of Nitrogen (NOx)		(ppmvd)	*optional input*
Nitrogen (N_2)		(vol. %)	*optional input*
NOx	21.9 lb/hr	0.161 (lb/MMBtu)	NOx emissions from test data: 164.7 lb/MMSCF ~0.170 lb/MMBtu

3 Engine Parameters

				Comments
Total Operating Hours per Season	8760	(hrs)	100% utilization	

4 Final Exhaust Gas Composition

			Comments
Oxides of Nitrogen (NOx)	5.5 lb/hr	0.040 (lb/MMBtu)	Assume 75% reduction

5 Economic Parameters

			Comments
Source of Cost Data	see Analysis		Analysis primarily relying on EPA Cost Manual

Direct Costs		**Cost Formula**	**Comments**
Combustion Control Equipment and Auxiliary Equipment	$2,765,000	(A)	Based on EPA control cost manual ($167/kw; adjust to 2020$)
Instrumentation	$276,500	(0.1*A)	Calculated Cost using EPA Control Cost Manual
Sales Taxes	$91,245	(0.03*(A+instrumentation))	3% Sales Tax in this example
Freight	$138,250	(0.05*A)	Calculated Cost using EPA Control Cost Manual
Purchased Equipment Cost (PEC)	**$3,270,995**	PEC	

6 Direct Installation Costs

		Cost Formula	**Comments**
Foundations and Supports	$261,680	(0.08*PEC)	Calculated Cost using EPA Control Cost Manual
Handling and Erection	$457,940	(0.14*PEC)	Calculated Cost using EPA Control Cost Manual
Electrical	$130,840	(0.04*PEC)	Calculated Cost using EPA Control Cost Manual
Piping	$65,420	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Insulation for ductwork	$32,710	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Painting	$32,710	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Site Preparation	$0	SP	As required
Buildings	$0	Bldg	As required
Total Installation Cost (TIC)	**$981,300**		
Total Direct Costs (PEC+TIC)	**$4,252,295**		

7 Indirect Costs

		Cost Formula	**Comments**
Engineering	$327,100	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Construction and field expenses	$163,550	(0.05*PEC)	Calculated Cost using EPA Control Cost Manual
Contractor fees	$327,100	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Start-up	$65,420	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Performance test	$32,710	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Contingencies	$98,130	(0.03*PEC)	Calculated Cost using EPA Control Cost Manual
Total Indirect Costs (IC)	**$1,014,008**	(0.31*PEC)	

8 Capital Cost Summary

		Comments
Total Direct Capital Costs (DC)	$4,252,295	
Total Indirect Capital Costs (IC)	$1,014,008	
Total Capital Investment (TCI)	**$5,266,303**	

9 Direct Annual Costs

		Cost Formula	**Comments**
Operator Labor	$12,500	nominal cost	0.5 hr/shift; example from similar EPA analysis
Supervisor Labor	$1,875		15% of operator
Operating Materials - ammonia	$22,530		materials estimate annual NH3 at $700 per ton; 1.1 molar ratio
Maintenance - Labor	$12,500	nominal cost	0.5 hr/shift; rate example from EPA
Maintenance - Materials	$5,000	nominal cost	Engineering Estimate
Catalyst maintenance / replacement	$138,250		Engineering Estimate (5% of Cap Cost)
Testing and QA/QC	$20,000		Engineering estimate - Annual test; reagent controller QA
Electricity	$2,500		Estimate based on analysis in PA DEP TSD
Total Direct Annual Costs	**$215,155**		

10 Indirect Annual Costs

		Cost Formula	**Capital Recovery Factor**	**Comments**
Overhead	$19,125	(0.6*(OL+SL+ML+MM))		
Administrative Charges	$105,326	(0.02*TCI)		Engine ACT Document
Property Taxes	$52,663	(0.01*TCI)		Engine ACT Document
Insurance	$52,663	(0.01*TCI)	**CRF**	
Capital Recovery	$422,358	CRF[TCI]	0.0802	Factor for costs annualized over 20 years at 5% interest.
Total Indirect Annual Costs	**$652,135**			CRF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = 0.1)

11 Summary

			Comments
Total Direct Annual Operating Costs	$215,155		
Total Indirect Annual Operating Costs	$652,135		
Total Annual Costs	$867,289	$61 $ per hp	
Incremental Annual Costs Over Baseline	$867,289		

12 Annual Emissions Reduction Over Baseline

		Comments
Oxides of Nitrogen (NOx)	71.85 (Tons)	

Cost Effectiveness ($/Ton)

		Comments
Oxides of Nitrogen (NOx)	$12,071	

NOx Control Cost Effectiveness Estimate

Engine Manufacturer	Cooper-Rolls
Model No.	Coberra 125
Engine Type	
Fuel Used	Natural Gas
Emissions Control	SCR
Combustion Control Purpose	NOx
Target Reduction	75%

Color Legend

User Data / Information Input Cell
"Cumulative" Cost Cell for Primary Categories
Cost Effectiveness ($ / ton)

1 Engine Design Conditions

			Comments
Power Output	14300	(hp)	Rated HP
Engine Exhaust Temperature		(F)	*optional input*
Engine Exhaust Rate		(lb/hr)	*optional input*
Gas Volume		(dscfm)	*optional input*

2 Full Load Engine Exhaust Composition:

			Comments
Oxygen (O_2)		(vol. %)	*optional input*
Carbon Dioxide (CO_2)		(vol. %)	*optional input*
Water (H_2O)		(vol. %)	*optional input*
Oxides of Nitrogen (NOx)		(ppmvd)	*optional input*
Nitrogen (N_2)		(vol. %)	*optional input*
NOx	23.1 lb/hr	0.170 (lb/MMBtu)	NOx emissions from test data: 172.9 lb/MMSCF ~0.170 lb/MMBtu

3 Engine Parameters

				Comments
Total Operating Hours per Season	8760	(hrs)	100% utilization	

4 Final Exhaust Gas Composition

			Comments
Oxides of Nitrogen (NOx)	5.8 lb/hr	0.043 (lb/MMBtu)	Assume 75% reduction

5 Economic Parameters

			Comments
Source of Cost Data	see Analysis		Analysis primarily relying on EPA Cost Manual

Direct Costs		**Cost Formula**	**Comments**
Combustion Control Equipment and Auxiliary Equipment	$2,765,000	(A)	Based on EPA control cost manual ($167/kw; adjust to 2020$)
Instrumentation	$276,500	(0.1*A)	Calculated Cost using EPA Control Cost Manual
Sales Taxes	$91,245	(0.03*(A+instrumentation))	3% Sales Tax in this example
Freight	$138,250	(0.05*A)	Calculated Cost using EPA Control Cost Manual
Purchased Equipment Cost (PEC)	**$3,270,995**	PEC	

6 Direct Installation Costs

		Cost Formula	**Comments**
Foundations and Supports	$261,680	(0.08*PEC)	Calculated Cost using EPA Control Cost Manual
Handling and Erection	$457,940	(0.14*PEC)	Calculated Cost using EPA Control Cost Manual
Electrical	$130,840	(0.04*PEC)	Calculated Cost using EPA Control Cost Manual
Piping	$65,420	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Insulation for ductwork	$32,710	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Painting	$32,710	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Site Preparation	$0	SP	As required
Buildings	$0	Bldg	As required
Total Installation Cost (TIC)	**$981,300**		
Total Direct Costs (PEC+TIC)	**$4,252,295**		

7 Indirect Costs

		Cost Formula	**Comments**
Engineering	$327,100	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Construction and field expenses	$163,550	(0.05*PEC)	Calculated Cost using EPA Control Cost Manual
Contractor fees	$327,100	(0.10*PEC)	Calculated Cost using EPA Control Cost Manual
Start-up	$65,420	(0.02*PEC)	Calculated Cost using EPA Control Cost Manual
Performance test	$32,710	(0.01*PEC)	Calculated Cost using EPA Control Cost Manual
Contingencies	$98,130	(0.03*PEC)	Calculated Cost using EPA Control Cost Manual
Total Indirect Costs (IC)	**$1,014,008**	(0.31*PEC)	

8 Capital Cost Summary

		Comments
Total Direct Capital Costs (DC)	$4,252,295	
Total Indirect Capital Costs (IC)	$1,014,008	
Total Capital Investment (TCI)	**$5,266,303**	

9 Direct Annual Costs

		Cost Formula	**Comments**
Operator Labor	$12,500	nominal cost	0.5 hr/shift; example from similar EPA analysis
Supervisor Labor	$1,875		15% of operator
Operating Materials - ammonia	$23,789		materials estimate annual NH3 at $700 per ton; 1.1 molar ratio
Maintenance - Labor	$12,500	nominal cost	0.5 hr/shift; rate example from EPA
Maintenance - Materials	$5,000	nominal cost	Engineering Estimate
Catalyst maintenance / replacement	$138,250		Engineering Estimate (5% of Cap Cost)
Testing and QA/QC	$20,000		Engineering estimate - Annual test; reagent controller QA
Electricity	$2,500		Estimate based on analysis in PA DEP TSD
Total Direct Annual Costs	**$216,414**		

10 Indirect Annual Costs

		Cost Formula	**Capital Recovery Factor**	**Comments**
Overhead	$19,125	(0.6*(OL+SL+ML+MM))		
Administrative Charges	$105,326	(0.02*TCI)		Engine ACT Document
Property Taxes	$52,663	(0.01*TCI)		Engine ACT Document
Insurance	$52,663	(0.01*TCI)	**CRF**	
Capital Recovery	$422,358	CRF[TCI]	0.0802	Factor for costs annualized over 20 years at 5% interest.
Total Indirect Annual Costs	**$652,135**			CRF = i * (1+i)^n / [(1+i)^n - 1] (i expressed as a decimal - e.g., 10% = 0.1)

11 Summary

			Comments
Total Direct Annual Operating Costs	$216,414		
Total Indirect Annual Operating Costs	$652,135		
Total Annual Costs	$868,549	$61 $ per hp	
Incremental Annual Costs Over Baseline	$868,549		

12 Annual Emissions Reduction Over Baseline

		Comments
Oxides of Nitrogen (NOx)	75.87 (Tons)	

Cost Effectiveness ($/Ton)

		Comments
Oxides of Nitrogen (NOx)	$11,449	